CENTRAL YUKON PLANNING AREA
OIL AND GAS ASSESSMENT

by

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EXECUTIVE SUMMARY

We classify the Central Yukon Planning Area as having NO to LOW potential for the occurrence of oil and/or gas. That part of the planning area underlain by Cretaceous and younger sedimentary rocks we have classified as having a LOW potential for the occurrence of oil and gas. The Nulato well, the only well drilled in the planning area, encountered neither oil shows nor reservoir-quality rock. The depositional environment, however, offers a slim possibility of reservoir rock in the northern or western portion of the refuge, adjacent to the Yukon River. The complicated structure of the sedimentary rocks in the area indicates that the possibility of any economic deposits is extremely small. We, therefore, classify the entire area as having NO potential for economic deposits of oil or gas.

INTRODUCTION

The U.S. Bureau of Land Management (BLM) manages about 9.5 million acres of public lands in the Central Yukon Planning Area (CYPA). These lands are located in west-central Alaska in the Shungnak, Hughes, Bettles, Candle, Kateel River, Melozitna, Tanana, Norton Bay, Nulato, Ruby, and Kantishna 1° by 3° quadrangles (Figure 1). The BLM-Alaska State Director signed the Record of Decision for the CYPA Resource Management Plan (RMP) on October 26, 1986. This increased the land open to oil and gas leasing from 69,000 acres to 8,768,334 acres.

The RMP, however, does not meet National Environmental Protection Act requirements and needs to be revised. The RMP does not adequately address the management of minerals, especially the management of oil and gas. This assessment of the oil and gas resource potential should assist in the revision of the RMP.

LANDS INVOLVED

The CYPA RMP lays out BLM's management plan for public lands within five subunits. These include the Nulato Hills, Hughes, Tozitna, Dulbi-Kaiyuh Mts., and Kuskokwim subunits (Figure 1 and Figure 2).

HISTORY OF GEOLOGIC EXPLORATION

Gold prospectors and a U.S. Geological Survey (USGS) geologist first explored the area in the vicinity of the CYPA in the late 1890s. Prospectors first entered the area in 1898. They found no gold until 1906, when Thomas Gane and his compatriots found gold on what is now Ganes Creek, Innoko Mining District. Spurr, a USGS geologist, traveled down the Yukon past the present site of Ruby in 1896. He inspected crystalline limestones that outcrop along the southern bank of the river. In 1898, he explored the Kuskokwim River.

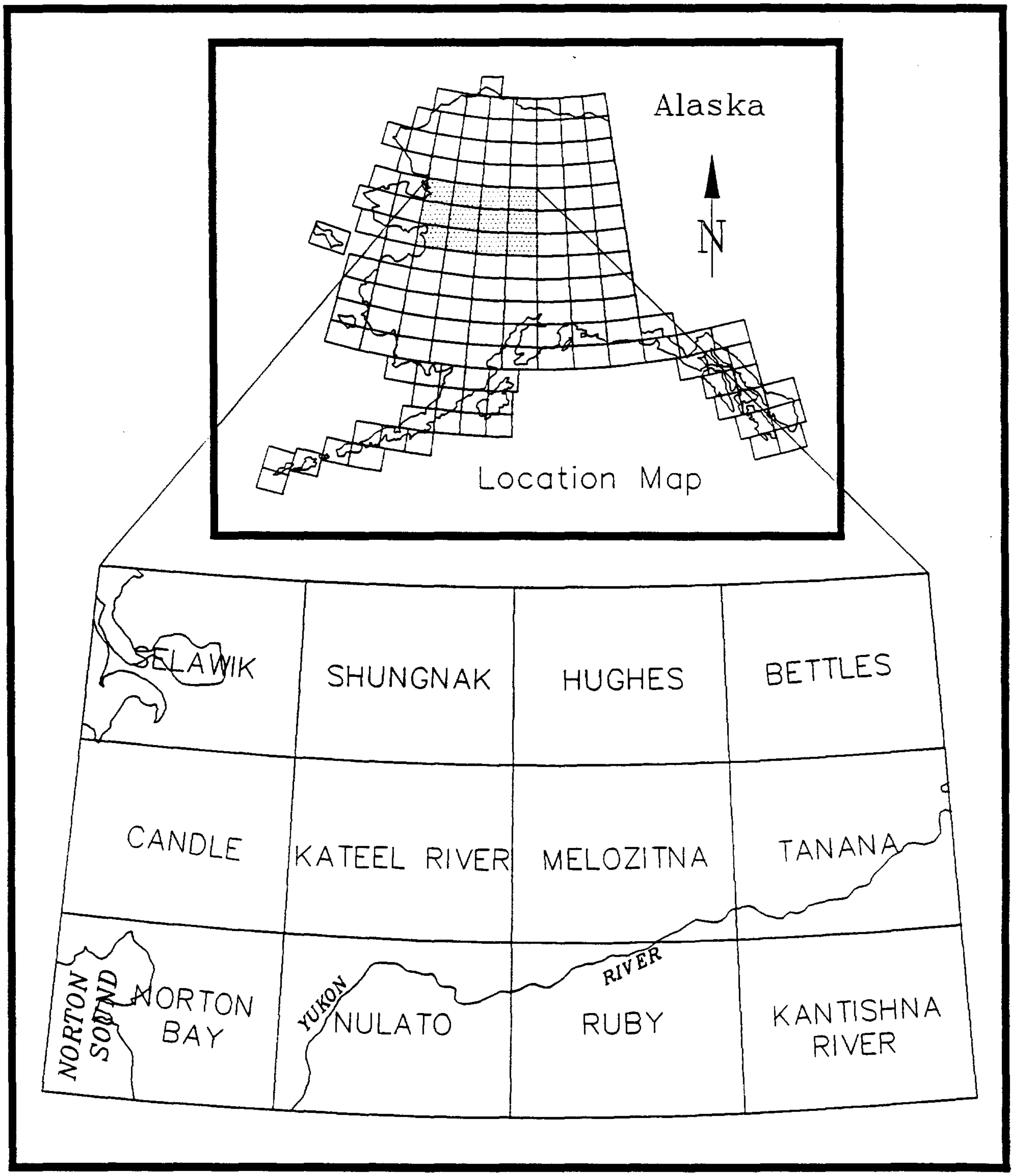


Figure 1. Location of the Central Yukon Planning Area by U.S. Geological Survey quadrangle.

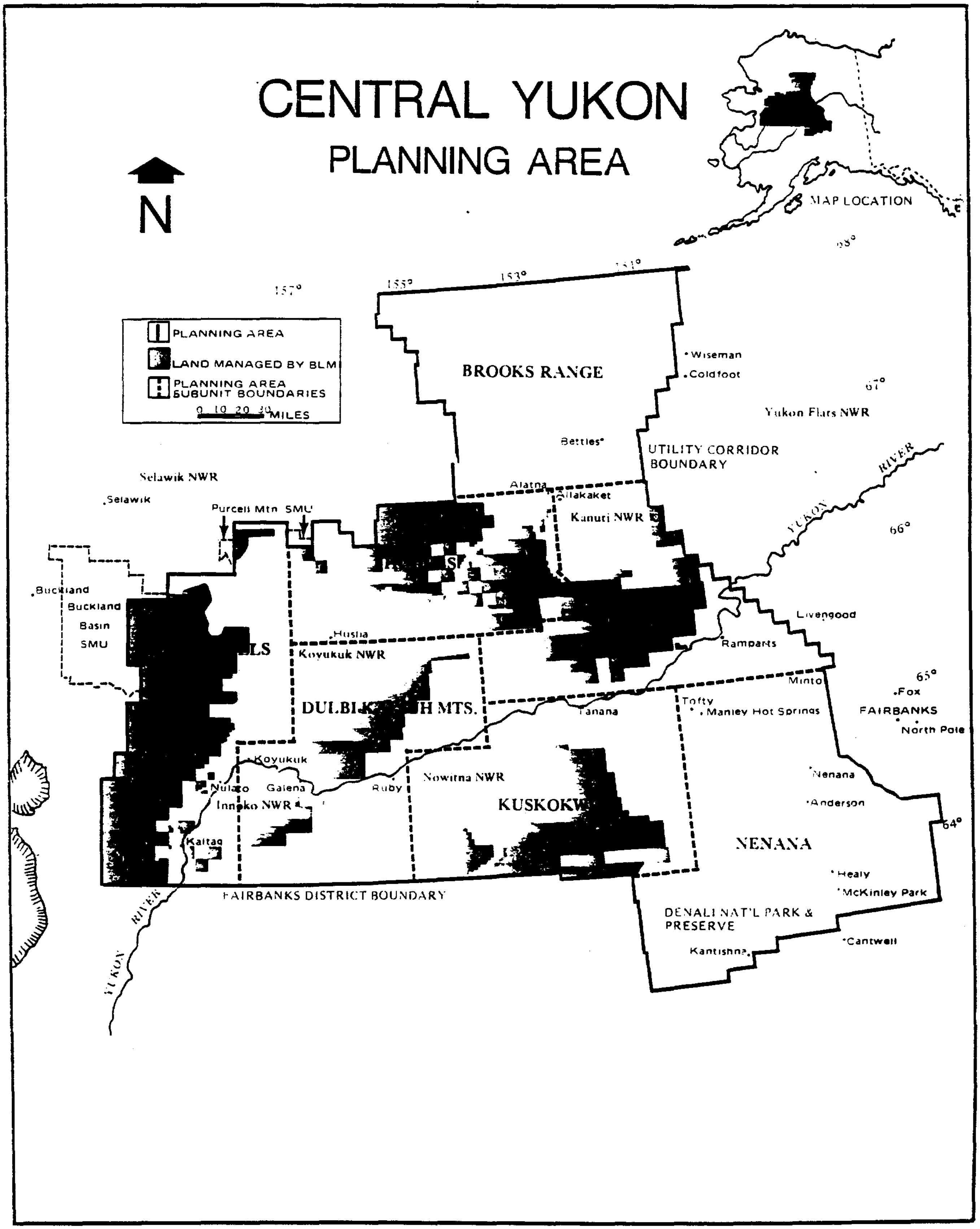


Figure 2. Map showing subunits of the Central Yukon Planning Area.

Several USGS geologists, including Collier, Maddren, Anderson, Eakin, Harrington, and Martin, and a Smithsonian Institution geologist, Gilmore, visited the general vicinity by 1920 (Mertie and Harrington, 1924). Mertie and Harrington prepared reports on the area in the 1920s and 1930s (Mertie and Harrington, 1924; Mertie, 1937).

The area received scant attention in the geologic literature until the 1950s. Since the 1950s, interest in this area has increased. The oil industry explored large parts of the area from 1954-1961. They drilled an exploratory oil well, the Nulato No. 1, near Nulato in 1960-1961. This well was drilled partly on the unconfirmed report of an oil seep in the vicinity (Patton, 1971).

The acceptance of the theories of plate tectonics and tectonostratigraphic terranes (defined below) has contributed to the increase in interest. Alaska, considered a good example of tectonostratigraphic terranes, has attracted many researchers in the past three decades, with the U.S. Geological Survey being quite active in the area.

ALASKAN OILFIELDS

The only operating oil or gas fields for onshore Alaska are on the North Slope and in the Cook Inlet-Kenai Peninsula area. Historically, the Katalla Field, near the mouth of the Copper River was the first producing oil field in Alaska. It has long since ceased production.

None of these fields occur near the CYPA, and they have no bearing on the oil and gas potential of the planning area.

GEOLOGY

The CYPA lies south of the Brooks Range, west of the Seward Peninsula, northeast of the Yukon-Kuskokwim delta, and northwest of the Alaska Range.

This is a large area of varied geology, probably most readily discussed in terms of the tectonostratigraphic terranes identified within the area and the Cretaceous and Cenozoic sedimentary and igneous rocks.

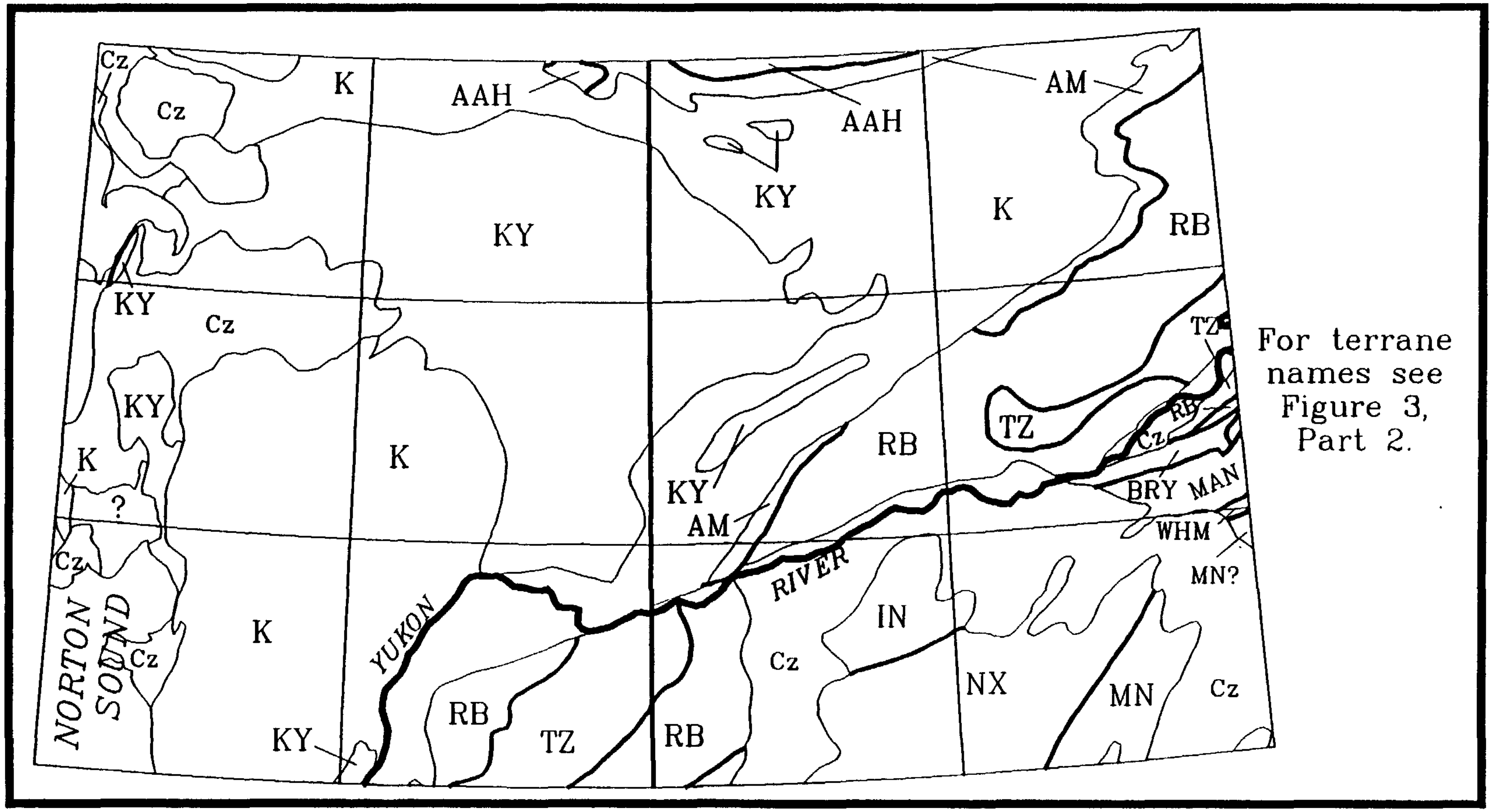
A tectonostratigraphic terrane is a fault-bounded block having a tectonic and geologic history which differs from surrounding rocks. The CYPA encompasses all or parts of several terranes: the Yukon-Koyukuk terrane (province), the Hammond subterrane of the Arctic Alaska terrane, the Angayucham terrane, the Baldry terrane, the Innoko terrane, the Manley terrane, the Minchumina terrane, the Nixon Fork terrane, the Ruby terrane, the Tozitna terrane, and the Yukon-Tanana terrane (Figure 3). Researchers have not uniformly accepted the delineations of and relationships among the various terranes, so some disagreements exist.

The Yukon-Koyukuk terrane (province or basin) appears to have the most potential for oil and gas resources in the CYPA.

The Nixon Fork terrane, based on the rocks present, appears to have the next greatest, but quite low, potential. The other terranes, because of the rocks present and because of the structural complexities, have little or no potential. So we will concentrate on the Yukon-Koyukuk terrane and only briefly describe the other terranes.

Yukon-Koyukuk Terrane:

The Yukon-Koyukuk terrane, as used in this report, includes the Yukon-Koyukuk basin, the Koyukuk-Kobuk basin, and the Koyukuk terrane (a U-shaped belt of igneous and volcanic rocks). It is a wedge-shaped basin open to the southwest. It lies between the Brooks Range, Seward Peninsula, and the Ruby geanticline (Ruby Terrane). A "U-shaped" outcrop belt of volcanic rocks divides the terrane into two subbasins: an outer, remnant-forearc basin (the Koyukuk-Kobuk subbasin) to the north and east of the belt of volcanic rocks, and an inner, remnant-backarc basin (the Yukon-Koyukuk subbasin) to the south



For terrane names see Figure 3, Part 2.

Figure 3, Part 1. Tectonostratigraphic terrane map for the Central Yukon area. (after Jones et al., 1987).

Terranes

AAH – Hammond Subterrane
AM – Angayucham Terrane
BRY – Baldry Terrane
IN – Innoko Terrane
KY – Koyukuk Terrane
MAN – Manley Terrane
MN – Minchumina Terrane
NX – Nixon Fork Terrane
RB – Ruby Terrane
TZ – Tozitna Terrane

Overlying Sedimentary Deposits

Cz – Cenozoic Deposits
K – Cretaceous deposits

The Koyukuk Terrane and the Cretaceous deposits around it are discussed as the Yukon–Koyukuk Terrane.

Figure 3, Part 2. Terrane names for tectonostratigraphic terrane map.

and southwest of the belt of volcanic rocks. The volcanic belt arcs through the terrane from Kotzebue Sound to the Yukon River. A part of the belt appears to lie to the south of the main outcrop of volcanic rocks.

The "U-shaped" outcrop belt consists of a thick Lower Cretaceous assemblage of marine andesitic volcanic rocks that include tuffs, breccias, and flows with local intercalations of volcanic graywackes and impure fossiliferous limestone (Patton, 1971). Rocks of similar affinities unconformably overlie pre-Cretaceous volcanic and plutonic rocks which crop out to the south of the main volcanic sequence about midway between Norton Sound and the Yukon River. This outcrop lies between the Chiroskey and Anvik faults. The pre-Cretaceous rocks include altered basalts of uncertain age, but younger than Middle Jurassic, and diorite and tonalite of Middle and Late Jurassic age (Patton and Moll, 1984). The western margin of the Koyukuk-Kobuk subbasin likewise consists of Lower Cretaceous andesitic rocks resting on older pillow-basalts. The andesitic rocks consist of pyroclastic and epiclastic strata deposited in subaerial to shallow submarine environments (Box, Carlson, and Patton, 1984). The K-Ar age of the basal island-arc sequence ranges from 173 to 100 million years. A suite of alkalic plutons, 113-100 million years old, intrudes Lower Cretaceous (Neocomian) andesites in the western part of the terrane (Harris, Stone, and Turner, 1987). Middle Lower Cretaceous K-feldspar-bearing tuffs, deposited in deeper water (a sub-wave-base environment) succeed the shallow-water facies in the Koyukuk Basin (Patton, 1971; Box, Carlson, and Patton, 1984). Upper Lower Cretaceous, medium-grained turbidites conformably onlap the tuffs. The composition of these turbidites (graywackes and mudstones) shows derivation from the ophiolite rocks of the Angayucham terrane and the schistose rocks of the Brooks orogen (Box, Carlson, and Patton, 1984). Middle Cretaceous (Albian-Cenomanian) hemipelagic shales (basin plain?) and sandstones, indicative of a mid-fan (channel?) environment, overlies the Lower Cretaceous sediments. These middle Cretaceous sediments onlap the marine volcanic rocks (Box, Patton, and Carlson, 1985). Calc-alkaline plutons, with K-Ar ages of

89-79 million years, intrude the Albian (late Early Cretaceous) sediments and the Neocomian (early Early Cretaceous) andesites in the eastern Yukon-Koyukuk terrane. Also in the eastern part of the terrane, the turbidite deposits grade upward into nonmarine, fluvial-deltaic deposits which contain Late Cretaceous plant and invertebrate fossils. A sequence of Late Cretaceous molasse, shed from the Brooks Range and adjacent borderland, occurs along the northern margin of the terrane.

In the Yukon subbasin, a lower unit of graywacke and mudstone overlies the andesitic volcanic assemblage and underlies an upper unit of shallow-marine and fluvio-deltaic deposits of sandstone and shale. The graywacke-mudstone unit crops out along the Norton Sound coast and contains no fossils. Correlation with similar crops elsewhere in the Yukon-Koyukuk terrane suggests a late early Cretaceous (Albian) age. The succeeding shallow-water sands and shales contain abundant marine fossils of late Early and early Late Cretaceous (Albian-Cenomanian) age (Patton and Moll, 1984). These shallow-water sands and shales occur mainly around the edge of the terrane.

Felsic volcanics (Harris, Stone, and Turner 1987) mark the end of the final phase of deposition in the Yukon-Koyukuk terrane. These rocks consist of rhyolite, trachyte, latite, andesite, and minor dacite and basalt. The K-Ar ages for these rocks fall into two groups: 56-49 and 44-43 million years (Early Eocene to lower Mid-Eocene and late Mid-Eocene, respectively).

Angayucham Terrane:

The Angayucham terrane is a structurally and stratigraphically complex assemblage of oceanic rocks. The rocks consist of gabbro, diabase, pillow basalts, tuff, chert, graywacke, argillite, and minor limestone. The sedimentary rocks range in age from Mississippian to Jurassic. Separate thrust sheets of plutonic ultramafic rocks occur throughout the terrane (Silberling and Jones, 1984).

The Angayucham terrane crops out discontinuously for about 900 km along the northern and southeastern margins of the Yukon-Koyukuk terrane (Loney and Himmelberg, 1985). Gravity and magnetic highs, coincident with the northern and southeastern margins of the Yukon-Koyukuk terrane, form a "V" open to the southwest. A model assuming dense, magnetic sources that dip 30-70 degrees toward the Yukon-Koyukuk terrane best fits the data (Cady, 1986). Cady (1986) assigns the northern arm to the Angayucham terrane and the southeastern arm to the Kanuti terrane on the basis of geology and geophysics. The Angayucham structurally overlies the Ruby terrane on the southeast and the Arctic Alaska terrane on the north (Silberling and Jones, 1984).

Hammond Subterrane of the Arctic Alaska Terrane:

The Hammond subterrane of the Arctic Alaska terrane consists of a structurally complex and polymetamorphosed assemblage. This assemblage has Paleozoic and older carbonate rocks, calc-schist, quartz-mica schist, quartzite, and metarhyolite. Late Devonian gneissic granitic rocks intruded this assemblage. A sparse sampling of radiometric ages suggest that Precambrian basement may occur locally (Jones et al., 1987).

Baldry Terrane:

The Baldry terrane also consists of a complex and polymetamorphosed assemblage. Here, the rocks consist of radiolarian chert, marble, greenschist, and mica schist. The protolithic and metamorphic ages are undetermined, but the protoliths are probably early to middle Paleozoic (Jones et al., 1987).

Innoko Terrane:

An assemblage of folded and disrupted chert, argillite, minor graywacke, limestone blocks, and volcanogenic sandstone make up the Innoko Terrane. Cherts date from the Late Devonian to Late Triassic. Limestones date mainly

to the Carboniferous. The sedimentary rocks have a similarity to the sedimentary rocks of the Angayucham Terrane without the large volume of pillow basalt, gabbro, and diabase (Silberling and Jones, 1984). Three gross lithologic units make up this structurally complex terrane. The lower unit consists of varicolored bedded chert with scattered, thin, lenticular bodies of limestone. The middle unit consists mostly of tuff, volcanic conglomerate, breccia, and basalt. An unconformity overlies the lower and middle units. The upper unit consists of a thick sequence of tuff, volcanic sandstone, and volcanic conglomerate (Patton, 1978).

Manley Terrane:

The Manley terrane consists of complexly deformed flyschoid Mesozoic sedimentary rocks. These include Upper Triassic argillite and chert, Upper Jurassic quartzite which contains clasts of Upper Triassic chert, graywacke-pelilte flysch with Valanginian and Albian fossils, and volcanic conglomerate of uncertain age. Mid-Cretaceous granitic rocks, and gabbro and serpentite of uncertain age, intrude the sedimentary rocks (Jones et al., 1987).

Minchumina Terrane:

The Minchumina terrane consists of a complexly folded assemblage of chert, argillite, and minor quartzite. Radiolarians and graptolites suggest that these rocks are of Ordovician age. Devonian chert may also be present (Jones et al., 1987).

Nixon Fork Terrane:

The Nixon Fork terrane is a stratified sequence of Ordovician to Upper Devonian reefal and platformal carbonates. These were deposited on Precambrian basement and are overlain by Permian, Triassic, and Cretaceous

fossiliferous sedimentary rocks. The basements rocks consist of peliltic and calcareous schists with minor amounts of marble, quartzite, and felsic metavolcanic rocks. The Permian strata contain clasts of the basement rocks (Jones et al., 1987).

Ruby Terrane:

The Ruby terrane contains some of the oldest rocks in Alaska. It consists mostly of a complex suite of metamorphic rocks of Precambrian to late Paleozoic age (Miller and Bundtzen, 1987). The metamorphic rocks include phyllite, quartzite, a greenschist to amphibolite facies pelitic schist, quartzofeldspathic gneiss, marble, and amphibolite (Smith and Puchner, 1985). Granites of mid-Cretaceous age (115-100 Ma) intrude the Ruby terrane (Miller, 1985).

Allochthonous sheets of Mississippian to Jurassic oceanic crustal rocks (Angayucham terrane) structurally overlie the Ruby terrane (Dillon, et. al., 1985). Isotopic and gravity data indicate that the Ruby terrane does not underlie the Yukon-Koyukuk terrane (Patton and Box, 1985).

Precambrian to Paleozoic metamorphic rocks form a broad, southwest trending belt from the Galena-Ruby area, on the Kaltag Fault, southwestward to Goodnews Bay. North of the Kaltag Fault, they form a discreet belt called the Kokrines-Hodzana Highlands (Gemuts, Puchner, and Steffel, 1983). Ruby terrane rocks crop out in the Kaiyuh Mountains, Tlatl Hills, and some of the other hills in the vicinity of the CYPA.

Tozitna Terrane:

The Tozitna terrane consists of a structurally complex assemblage of gabbro, pillow basalt, massive basalt and diabase, argillite, tuff, chert, graywacke, minor conglomerate, and limestone. Comminuted prismatic bivalve

shells make up the Permian(?) limestones. Radiolarian cherts range from Mississippian to Triassic age. Sparse radiometric ages (K/Ar) from gabbros are late Triassic, but Paleozoic basaltic rocks are probably present. This terrane includes the Rampart Group of east-central Alaska (Silberling and Jones, 1984).

STRUCTURE

The Yukon-Koyukuk terrane is a broad, asymmetric, "V-shaped," depression open to the southwest (Harris, Stone, and Turner, 1987). Along its northern and southeastern margins a narrow, highly-tectonized belt of Mesozoic-aged oceanic rocks (Angayucham terrane) overthrusts the Paleozoic metamorphic borderland (Cady, 1986). This oceanic crust dips toward the Yukon-Koyukuk terrane and may form the basement of the basin. Terrigenous strata overlap the oceanic crust and metamorphic rocks along the margin (Patton and Moll, 1982).

The Yukon-Koyukuk terrane has tightly folded and highly faulted strata. Folds trend northeastward along the southeastern margin and east-west along the northern margin. The Early and Middle Cretaceous rocks are intensely folded on a scale that ranges from inches to miles (Lyle et al, 1982; Harris, Stone, and Turner, 1987), and numerous intrusive bodies cut the strata (Miller, Payne, and Gryc, 1959). The latest Cretaceous or earliest Tertiary volcanic rocks are broadly warped and dip, generally, less than 40°. Late Tertiary or Quaternary basalt flows are essentially undeformed (Patton and Moll, 1984). Few, if any, anticlinal structures, remain unbroken by pervasive north and northeast trending faults (Gates, Grantz, and Patton, 1968).

A broad structural high, the "Hogatza trend," extends across the terrane from Kotzebue Sound to the valley of the Koyukuk River. It exposes a thick assemblage of marine andesitic volcanic rocks. This assemblage appears to underlie large parts of the Koyukuk Flats and the Kobuk-Selawik lowland (Patton, 1971).

A major strike-slip fault, the Kaltag Fault, cuts across the Yukon-Koyukuk terrane along an east-northeast trend. It shows right-lateral displacement (i.e., the rocks on one side of the fault have moved to the right relative to the rocks on the other side) of 100 to 130 kilometres (62 to 81 miles). Most of this movement occurred after deposition of the Cretaceous rocks (Lyle et. al.,1982; Patton and Moll, 1984).

TECTONIC DEVELOPMENT

As with the tectonostratigraphic terrane and structure discussions, we will concentrate on the tectonic development of the Yukon-Koyukuk terrane. We will consider the associated terranes only to the extent necessary for discussion of the Yukon-Koyukuk terrane.

The Ruby terrane may have formed as a rifted-away portion of the North American Continent at the end of the Paleozoic. This would have formed the Yukon-Koyukuk basin as a marginal sea or mini-ocean basin which existed from the late Paleozoic to the Early Cretaceous (Patton, 1976). Formation of the Ruby terrane as a rifted fragment would mean that extensional tectonics affected this area in the late Paleozoic. The change from extensional tectonics to compressive tectonics, as would be necessary for the subsequent development of the Yukon-Koyukuk Terrane, is not discussed in the literature.

Oceanic rocks (i.e., the rocks of the Angayucham terrane) overthrusted the margins of the Yukon-Koyukuk terrane (i.e., onto the rocks of the Ruby terrane) during the latest Jurassic (Tithonian) and Early Cretaceous (Berriasian) time (Patton and Box, 1985). This clearly implies that the tectonic regime had changed from extensional to compressional by this time. An island arc system, with its attendant arc volcanism, developed synchronously with this collision of the oceanic rocks with the irregular margin of the North American continent (Patton and Box, 1985; Cady, 1986). Continued collision of the island arc into a continental reentrant developed

the "U-shape" of the volcanic trend in the Yukon-Koyukuk Terrane (Box and Patton, 1985). During the Berriasian to Valanginian (Early Cretaceous), mostly clastic volcanic rocks collected in shallow marine to subaerial environments in the Koyukuk subbasin (to the northeast of the island arc system)(Box and Patton, 1986).

During the Hauterivian (middle Early Cretaceous) the area experienced marked subsidence accompanied by a change to highly potassic pyroclastic volcanism (Box and Patton, 1986). By the Barremian (possibly Aptian) the pyroclastic tuffs interbedded with turbidites derived from the uplifted Brookian metamorphic belt. The Brookian orogeny apparently originated from the attempted subduction of the North American margin beneath the intraoceanic island arc (Box and Patton, 1986). Significant volcanism ceased by the Albian (late Early Cretaceous) and the intervening trough filled with sediments derived from the Brooks Range. Terranes which accreted from the southeast in Late Cretaceous time further tightened the "U-shape" of the volcanic trend (Cady, 1986).

In the Yukon subbasin (to the south and southwest of the volcanic arc system), marine graywacke and mudstone compose nearly all of the Cretaceous sedimentary sequence along the west side of the terrane from the Seward Peninsula to the Yukon-Kuskokwim lowland. Sandstones, shales, conglomerates, and coal record deposition in shallow-marine and nonmarine environments around the perimeters of the terrane. These shallow marine and nonmarine sediments interfinger with the marine graywackes and mudstones and, in places, overlie the andesitic volcanic rocks of the island arc system. These sediments derived from the metamorphic borderlands which uplifted when of the island arc system collided with the continent (Patton, 1971).

A major episode of calc-alkaline volcanism during the Late Cretaceous and early Tertiary (70 to 60 million years ago) affected a broad area from the Bering Sea Shelf eastward to the Alaska Range and northward to the Arctic

Circle. A widespread occurrence of contemporaneous hypabyssal (minor) intrusive rocks of similar composition overlaps four tectonostratigraphic terranes: the Nixon Fork, Innoko-Rampart, Yukon-Koyukuk, and Brooks Range-St. Lawrence Island (the names of the terrane given here reflect some of the disagreement mentioned above). This overlap indicates that these terranes were sutured together by the end of Late Cretaceous time. Subduction along the Pacific margin during Late Cretaceous and early Tertiary time may have caused this calc-alkaline volcanism and contemporaneous plutonism (Moll and Patton, 1982).

Tertiary volcanics mark the end of the final phase of terrigenous sedimentation in the Yukon-Koyukuk terrane. The 56 to 49 million year old, mostly felsic volcanics tilt from about 20 degrees to about 50 degrees and record the final deformation of the Yukon-Koyukuk terrane. The 44 to 43 million-year-old group of undeformed basalts indicate no further tectonic tilting of the Terrane (Harris, Stone, and Turner, 1987).

The 100 to 130 kilometres of right-lateral offset of the Kaltag fault record post-Cretaceous strike slip deformation of the Yukon-Koyukuk terrane. Evidence suggests that this deformation continues.

RESERVOIR ROCKS

The shallow marine and nonmarine rocks around the edge of the Yukon-Koyukuk terrane offer the best possibility of having reservoir-quality rocks. These units have better sorting and contain a larger fraction of resistant rock and mineral detritus than do the underlying graywackes and mudstones (Patton, 1971). The impermeable graywackes and mudstones (Gates, Grantz, and Patton, 1968) have little probability of having reservoir-quality rocks. Within the boundaries of the CYPA, the shallow marine and nonmarine rocks occur in a band along the Yukon River. The well drilled just to the west of the refuge near Nulato, drilled to a depth of 12,000 feet, apparently encountered no reservoir rocks (Patton, 1971).

HYDROCARBON INDICATORS AND GEOCHEMISTRY

An unverified oil seep near Nulato (Gates, Grantz, and Patton, 1968) apparently provided one of the incentives for drilling the Nulato well. The well, however, apparently encountered no oil shows (Patton, 1971). Harris, Turner, and Stone (1985) reported that vitrinite reflectance values from two, mid-Late Cretaceous sedimentary sections plotted in the oil window of a time-temperature graph.

GEOPHYSICS

Gravity and magnetic highs correspond with the arms of the "V" formed by the Angayucham terrane and with the "U" formed by the island arc assemblage within the Yukon-Koyukuk terrane. The highs associated with the Angayucham terrane are asymmetric with steeper gradients to the outside. These highs can be modeled by assuming dense, magnetic sources that dip 30° to 70° inward beneath the Yukon-Koyukuk Terrane. The steep gradients coincide with boundaries determined by surface geology and strontium isotope data between oceanic terranes in the Yukon-Koyukuk terrane and nearby continental terranes. Isostatic constraints and gravity modelling preclude a model in which oceanic terranes are thrust over continental crust in the interior of the Yukon-Koyukuk terrane. Acceptable models include thickened oceanic crust or oceanic crust thrust over attenuated continental crust (Cady, 1985; Cady, 1986).

Old continental crust of the Brooks Range and the Ruby terrane produce gravity lows. Also, the middle Cretaceous clastic rocks which fill the subbasins of the Yukon-Koyukuk Terrane produce gravity lows (Cady, 1986).

The gravity highs indicate that dense rock lies near the surface and the gravity lows indicate that less dense rock lies near the surface. The magnetic highs indicate the presence of magnetic rock near the surface.

Aeromagnetic data indicate that the basin, north of the Kaltag Fault, may have as much as 25,000 feet of basin fill (Gates, Grantz, and Patton, 1968).

AREAS OF HYDROCARBON POTENTIAL

The parts of the CYPA underlain by the igneous, metamorphic and oceanic rocks of the various terranes we classify as having NO hydrocarbon occurrence potential because of the nature of the rocks and their structural complexity (Figure 4). The area that overlies the shallow marine and nonmarine sediments along the edge of the Yukon-Koyukuk Terrane has a LOW potential for the occurrence of hydrocarbons. We also classify the area of the Nixon Fork terrane as having a LOW, a very low, potential for the occurrence of oil and gas because it has sedimentary rocks with little structural complexity.

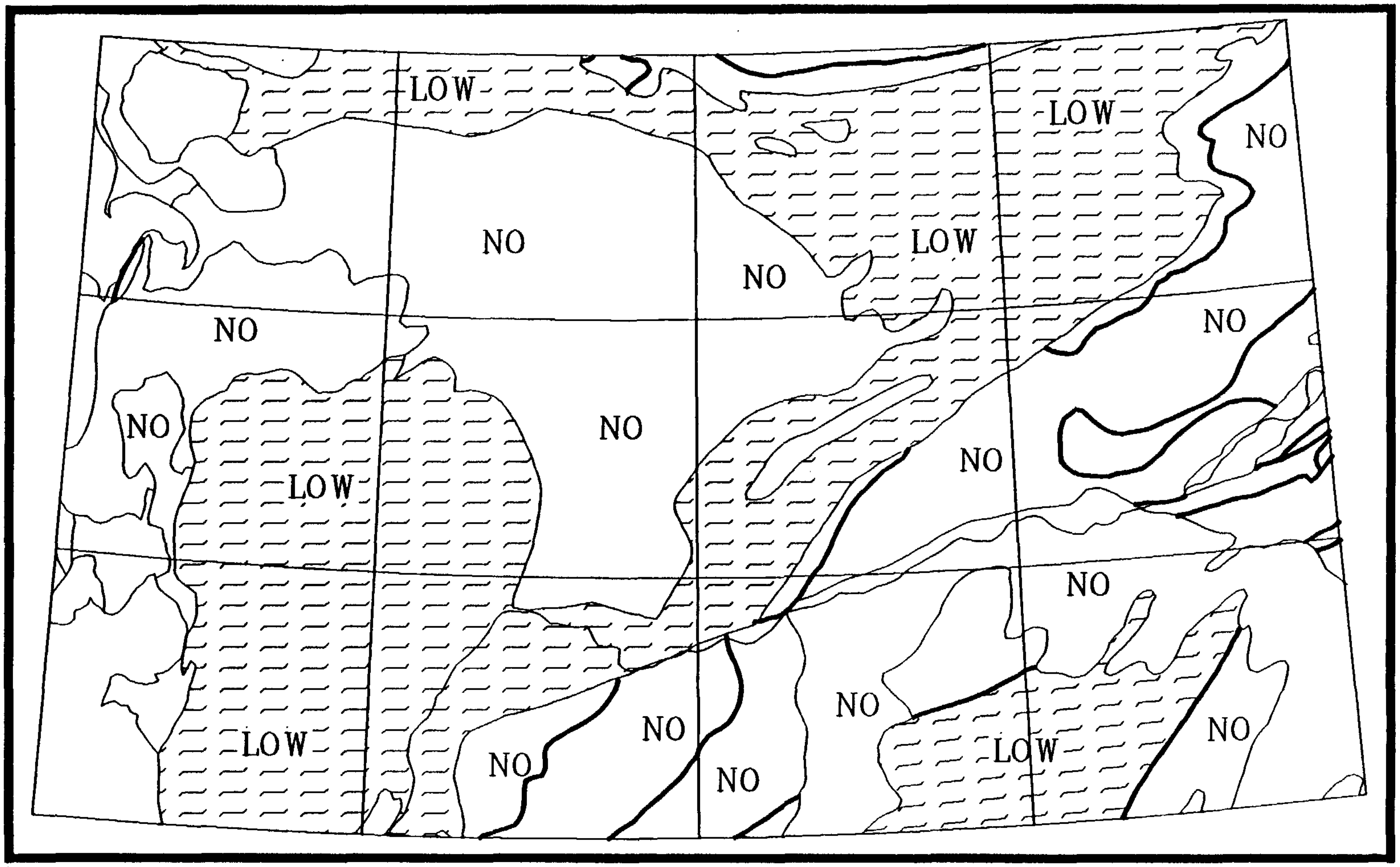


Figure 4. Geologic potential map for oil and gas in the Central Yukon Planning area. LOW potential is shown by the hatched pattern, and NO potential is shown by the unhatched area. (After Jones et al., 1987)

UNCONSTRAINED REASONABLY FORESEEABLE DEVELOPMENT SCENARIO

The oil and gas assessment classified the entire Central Yukon Planning Area as having NO potential for economic deposits of oil and gas. However, economic situations change and a portion of the area was classified as having LOW geologic potential for oil and gas. Therefore, a general scenario is presented to give the reader an idea of what may occur if economic and geologic conditions occur to warrant development. The development scenario presented below assumes the entire area is open to exploration and development under standard lease terms and operating conditions.

As stated in the mineral resource assessment, drilling activities in this area have been limited to one exploratory well. The well was drilled to 12,000 feet and abandoned and apparently no reservoir rocks were encountered. Due to the known information and distance to potential markets, it is highly unlikely that economically viable oil and/or gas resources exist in this area. However, there are many unknowns in a frontier area such as this, and the scenario below gives a general description of the activities which could occur if commercial quantities of these resources were discovered.

Exploration activities could consist of field geologic investigations and the collection of seismic data. Field investigations would be conducted during the summer months by helicopter or fixed-wing aircraft. Field workers, of two to six people, may be in the field for a couple of days or a couple of months. Generally, their activities include the observation of geologic features and the collection of rock samples from any outcrops. Impacts associated with this activity would be limited to establishment and operation of a camp. Seismic exploration would occur during the winter months when enough snow has accumulated on the surface to avoid any environmental impacts. Seismic data is generated by inducing sound waves into the subsurface and recording the reflected waves. To accomplish this, a crew of five to ten people with three to five vehicles would cross the area in a grid

pattern generating the sound waves and recording the reflected waves. The crew could be in the field for up to four months, depending on the quantity of information required. Environmental impacts would be minimal as this activity uses low-ground-pressure vehicles and is not initiated until after the ground is frozen and protected by snow.

Analyzed data, from the exploration activities, may generate interest in a particular structure which could lead to the drilling of an exploratory well. Purposes of this well are to gather more subsurface information and to find commercial quantities of oil and/or gas resources. Depending on what is or is not found, delineation wells will be drilled to confirm a discovery or the new information will be tied into existing information and the project may die or another exploratory well will be drilled.

Exploratory drilling is a large-scale operation using heavy equipment, but is usually confined to a localized area. For environmental, engineering, and economic reasons, exploratory drilling is usually done during the winter months. Construction equipment would be hauled overland by low-ground-pressure vehicles or barged up the Yukon River to the drilling site. For environmental reasons, an ice pad could be used to support the drilling rig and support equipment, if enough water is available near the site. Other methods of pad construction may be from excavated material, gravel-foam-timber, or other possible combinations. The pad would be large enough to hold the rig, support equipment, and to provide storage for drilling supplies (drillpipe, casing, sacked drilling mud and sacked cement, etc.). A typical pad (including reserve pit) covers two to four acres of ground surface. The pad would also support a camp providing sleeping and eating accommodations, power generator units, and storage space. Actual number of people at the site may vary, but it is estimated that 30-50 people would be continually present during the drilling activities.

The reserve pit would be excavated at the edge of the pad. It would be 10 to 20 feet deep and would cover 0.5 to 1.0 acres (parallel to the pad). Also, a small flare pit is excavated at the corner of the pit most distant from the rig which is used for gas flaring during well testing. Material excavated from these pits is used to level the drill pad, if needed, or is stockpiled. This material would be used to backfill the reserve pit upon pad abandonment.

Construction of an ice or gravel airstrip will be needed to support the exploratory drilling. A 12,000 foot well could be drilled, tested, and abandoned in 60 to 120 days. If all goes well, construction and drilling operations could be completed in one winter season. However, industry may elect to drill the well over two seasons to allow for unplanned delays. Operations would most likely be suspended during the summer months. The rig and supporting equipment would be laid down and supported on pilings until freeze-up and completion of a new ice pad. If a gravel pad and airstrip are constructed, operations could continue into the summer months.

Actual drilling operations begin by augering a hole 50-100 feet deep for the conductor casing. The drilling rig is then placed on the pad using pilings or timbers (prevents differential settling). Conductor casing is run and set and the well is spudded. The well will be drilled to a competent geologic formation where the surface casing will be set and cemented. A smaller diameter hole is then drilled to the target formation which would be tested and evaluated. After final testing and logging, the well is suspended or abandoned by placing cement plugs in the wellbore and casing.

Demobilization of the drilling rig starts immediately after the well is abandoned. All equipment is removed from the site and hauled to another drilling location. Any debris is picked up and transported to an approved disposal facility. A final clean-up crew would return to the site in the summer to pick up any remaining debris and to check on the rehabilitation.

Following a discovery by exploratory drilling, delineation wells would be drilled to confirm the existence of the resource in commercial quantities. The actual number and scheduling of delineation wells is dependent on the discovered reservoir. These wells would be drilled by the same method described above.

If the information obtained indicates a viable economic discovery, environmental studies would be conducted and a plan for the development and production of the reservoir would be submitted to government agencies for review, possible modification, and approval. Assuming a decision is made to proceed with the project and the plans are approved, on-the-ground activities would begin to develop, produce, and transport the resource to market.

The first activity associated with development is the extraction of gravel and the construction of the main road between the field and existing roads, drilling/production pads, and pipelines. An airstrip would also be constructed to support field operations. Once the main road is completed, permanent production facilities would be transported to the field. These facilities would be located on the production pads for the life of the field. Current data does not exist to accurately project the life of a field in this area, but one would expect an economic field to produce 10-25 years

At a proposed reservoir depth of 10,000 feet, each drilling pad would support 20-30 wells which would produce approximately 19,000 acres of a gas field and 5,000 acres of an oil field. This assumes the field is produced on 320 acres per well for gas and 160 acres per well for oil. The wellheads would be protected from the environment by metal buildings approximately 10 feet by 10 feet by 10 feet. For the purposes of this scenario, it is assumed that a 20,000-acre oil or gas field could be economically produced. Under this assumption, two pads would be needed to deplete a gas reservoir and four pads would be needed to deplete an oil reservoir. Most of these pads would be 15-20 acres in size. Once the field was depleted, the wells would be plugged and abandoned, the buildings removed, and the disturbed surface would be reclaimed per governmental regulations.

Other facilities required for the production of oil and gas are oil, gas, and water separators, pipelines, water disposal wells, and an office complex. Depending on the hydrocarbon reservoir parameters and the surface features of the field, separator facilities and a disposal well may be needed on all pads or just a few of them. Those pads requiring these facilities will be 25-30 acres to accommodate the buildings housing the separator and disposal equipment. One pad will also support the office complex which could contain a number of offices, kitchen, restrooms, meeting rooms, etc. The pad accommodating this building would be 30-35 acres. The buildings would be built on pilings or shallow spread footings to ensure foundation integrity and the pads would be approximately five feet thick and insulated to support heavy equipment and to protect the permafrost.

Roads will connect all of the facilities. They would be built with a crown width of 35 feet and would be five feet thick. Each mile of road will cover five acres of surface. Total road mileage varies, depending on the size and surface features of the field.

Gravel required for field operations would be mined from any local deposits in the area. A road would also be built from the gravel source to the field.

Pipelines will be present from each of the production pads. If separator facilities are located on each pad, only one line will run from the pad to the main production line. Fields utilizing one separation facility for two or more pads will have one to three lines from each pad. Pads may only have a production line run to the facility, or a production line to the facility and a water line from the facility to the pad for disposal, or a production line, water line, and a gas line from the facility to the pad for injection. Marketable oil and/or gas would be transported by pipeline. Gas lines would most likely be buried, but any oil pipelines would most likely be placed on vertical support members. Thsi same procedure was used on the Trans-Alaska

Pipeline System (TAPS). The size of these pipelines will be determined by the production levels of the field. One can assume that the pipelines in the field would range from three to six inches and the main pipeline out of the field would be six to twenty-four inches in diameter. Pipelines would probably be laid parallel to the roads.

Marketable gas could be utilized by any local towns and villages in this area. If a gas pipeline is built from the North Slope, gas could be piped and tied into this line. Oil production by pipeline would most lekely tie into the TAPS.

An airstrip would be permanent and maintained year-round for the lifetime of the project. The size of the airstrip would be 4,000-6,000 feet long and 100-150 feet wide. Use of the airstrip would be restricted to field operations and would be used for movement of personnel and field equipment and supplies.

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APPENDIX A

3031 - Energy and Mineral Resource Assessment

Mineral Potential Classification System*

I. Level of Potential

- O. The geologic environment, the inferred geologic processes, and the lack of mineral occurrences do not indicate potential for accumulation of mineral resources.

- L. The geologic environment and the inferred geologic processes indicate low potential for accumulation of mineral resources.

- M. The geologic environment, the inferred geologic processes, and the reported mineral occurrences and/or valid geochemical/geophysical anomaly indicate moderate potential for accumulation of mineral resources.

- H. The geologic environment, the inferred geologic processes, the reported mineral occurrences and/or valid geochemical/geophysical anomaly, and the known mines or deposits indicate high potential for accumulation of mineral resources. The "known mines and deposits" do not have to be within the area that is being classified, but have to be within the same type of geologic environment.

- ND. Mineral(s) potential not determined due to lack of useful data. This notation does not require a level-of-certainty qualifier.

II. Level of Certainty

- A. The available data are insufficient and/or cannot be considered as direct or indirect evidence to support or refute the possible existence of mineral resources within the respective area.

- B. The available data provide indirect evidence to support or refute the possible existence of mineral resources.

- C. The available data provide direct evidence but are quantitatively minimal to support or refute the possible existence of mineral resources.

- D. The available data provide abundant direct and indirect evidence to support or refute the possible existence of mineral resources.

For the determination of No Potential, use O/D. This class shall be seldom used, and when used, it should be for a specific commodity only. For example,

if the available data show that the surface and subsurface types of rock in the respective area is bathololithic (igneous intrusive), one can conclude, with reasonable certainty, that the area does not have potential for coal.

* As used in this classification, potential refers to potential for the presence (occurrence) of a concentration of one or more energy and/or mineral resources. It does not refer to or imply potential for development and/or extraction of the mineral resource(s). It does not imply that the potential concentration is or may be economic, that is, could be extracted profitably.

Consideration of the Potential for Development and the Economic Potential

Whenever known, the quality, quantity, current, and projected development potential or economic potential should be part of the mineral resource assessment. Although this is not necessary or required for most BLM actions, it is often useful to the decision maker. Assessments of economic potential should not be attempted for actions requiring low levels of detail, or when data are scant.

Development potential means whether or not an occurrence or potential occurrence is likely to be explored or developed within a specified timespan under specified geologic and nongeologic assumptions and conditions. Economic potential means whether or not an occurrence or a potential occurrence is exploitable under current or foreseeable economic conditions. The time period applicable to the economic or development potential assessment should be specified in the assessment report (e.g., the occurrence is likely to be exploited within the next 25 years). Conditions that could change the economic potential, such as access, world energy prices, or changing technology, shall be an important part of every economic potential assessment. Determining the economic or development potential of either an actual or an undiscovered mineral occurrence is a matter of professional judgment based on an analysis of geologic and nongeologic factors. The rationale for that judgment shall be part of the Mineral Assessment Report, when the economic potential is assessed. The rationale may include data on the current marketing conditions for the mineral commodity, technological factors affecting exploitability, distance from roads, anticipated capital costs, etc. In other words, if the economic or development potential is assessed, the rationale for the conclusions regarding that potential must be thoroughly documented.

Calculating the quality of an occurrence, where the quality and quantity are not known from existing data, is only done for actions requiring a high level of detail. These calculations involve methods appropriate to the type of action and are described in the pertinent Bureau Manual (e.g., appraisal, validity, etc.).